Toward a reflexive framework to compare collective design methods for farming system innovation

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Abstract

Faced with strong environmental issues, the agricultural sector has to revise deeply its aims and performance criteria. Numerous methods have been proposed to involve heterogeneous stakeholders in farming system design, and several authors highlight the importance of reflexivity in such projects. Our paper aims at strengthening this reflexivity by proposing a comparative analysis framework contributing to the assessment of participative design methods for rural innovation with regard to explorative innovation. We used a framework proposed by Charue-Duboc et al. (2010) as an entry point to build an analytical grid enriched by the empirical analysis of three different participatory design methods in order to make it operational. The new framework we propose makes it possible to assess the capacity of these methods to foster exploratory innovation and enhance reflexivity regarding farming system innovation.

Introduction

One of the major stakes farming system managers have to face is to transform their productive activities to cope with a range of environmental, social and economic problems. Many scholars state that sustainable development cannot take place without system innovation (van Mierlo, Arkesteijn et al. 2010), which means changes in whole systems of production and consumption, including social relationships, rules, values and technologies (Geels 2004). Holistic approaches are required (Vanloqueren and Baret 2009) to take into account the complexity of socio-ecological systems, which are multi-actors and multi-scales but also uncertain and unpredictable. Add-on incremental innovations based on problem-solving are not sufficient anymore and farming systems have to be thoroughly revised, involving new stakeholders, skills or institutions (Kemp 1994). The agricultural dominant regime based on the objective of increasing productivity has shown many flaws with regard to ecosystem and natural resource degradation. There is a need for a shift from the dominant design regime referring to exploitation of existing technologies towards the exploration of new knowledge and technologies to foster radical innovation (Green, Gavin et al. 1995) (Benner and Tushman 2003). The participation of a wider diversity of stakeholders is crucial to bring such new knowledge. Numerous and various participatory design approaches have been developed in the last decade to involve multiple stakeholders in agri-environmental innovations. However, several authors highlight the lack of reflexivity on these methods (Bos and Grin 2008) (van Mierlo, Arkesteijn et al. 2010), and the need to develop reflexive frameworks to analyse and compare them. This paper contributes to this work.

Theoretical framework

Farming system innovation may trigger both technical and organisational change (Sumberg and Reece 2004). In line with the distinction introduced by March (1991) between exploitation and exploration, our work differentiates two types of innovations according to the characteristics of the knowledge involved: (i) exploitative or incremental innovations designed to improve existing farming systems in order to achieve clearly identified new goals. Such innovation involves exploiting available knowledge and expanding existing technologies and practices without in-depth modification of the farming systems (Martin, Martin-Clouaire et al. 2011); (ii) exploratory or radical innovations for which objectives, performance criteria and required knowledge are not pre-identified. In the literature on organisational learning and the competence-based view (Greve 2007), exploratory innovation is considered as based on new knowledge regarding technologies and/or markets. According to the expected type of innovation, implications for the management of the design process involved as well as for their integration within a production system are different (Sumberg and Reece 2004).

System thinking in rural innovation requires the integration of new knowledge about ecosystem regulations, agricultural technologies and complex relationships between a growing range of farming system stakeholders (farmers, citizens, agro-industries, extension services…). As partial incremental improvements have become insufficient to cope with the accelerating environmental and socio-economic crises, exploration processes are needed, not only focusing on renewing knowledge but also on developing new business models (Teece 2010) and new partnerships (Segrestin 2006). The linear model of knowledge and technology transfer from research to farmers has to be replaced by processes involving heterogeneous stakeholders. Entering into an exploration partnership presupposes an agreement on the implementation of a learning process in which the modalities of cooperation and coordination, together with the sharing of risks and benefits, will be defined as the process advances (Segrestin 2006). Such exploration process raises strong management issues (Aggeri, Chanal et al. 2012).

Numerous organisational forms have been proposed to involve heterogeneous stakeholders in farming system design; they all have in common to bring together a variety of actors and facilitate the collective design of solutions (van Mierlo, Arkesteijn et al. 2010). However several authors highlight the fact that projects for system innovation must be reflexive. This means that they should enable the challenging of presumptions, current practices, and underlying institutions, either in the design of the project or in its management (Grin, Felix et al. 2004). Our paper aims at strengthening this reflexivity by proposing a comparative analysis framework contributing to the assessment of participative design methods for rural innovation with regard to explorative innovation.

Methodology

Research design

The framework we propose is based on the three dimensions proposed by Charue-Duboc et al. (2010) to manage exploratory innovation:
1. Managing knowledge for exploration (e.g. knowledge capitalisation, production and sharing)
2. Organising for exploration (e.g. how exchanges organised between actors influence knowledge acquisition)
3. Creating new value space (e.g. identification of new opportunities for value creation).

We used this framework as an entry point to build an analytical grid and apply it to the analysis of three different participatory design methods developed in the field of agricultural systems and natural resource management. This empirical analysis leads us to revise the framework developed by Charue-Duboc et al. to propose a more operational one.

Data collection

Our paper is based on the analysis of three case studies in which design workshops were organised using three different methods, and for which we were organisers and/or observers. The data on which we draw our analysis is based on individual interviews, analysis of scientific and administrative documents related to the design subject and participative observation of the workshops (as facilitators for ComMod and KCP, not for the Forage Rummy).

The three methods studied

The chosen methods are: the Companion Modelling Approach (ComMod), the Forage Rummy and a design method based on Concept-Knowledge design theory, named KCP (Knowledge-concepts-proposals). These three methods rely on collective design workshops organised by scholars involving stakeholders of a given agricultural system or natural resource. These methods are recent but have already been applied in various situations and have been the subject of several publications (see below). Although showing similar design aims, they differ significantly regarding stakeholders' involvement, objectives, procedure and tools, knowledge used and outcomes, as shown in the following description and in table 1.

1. ComMod

ComMod (Barreteau, Antona et al. 2003) is a participatory modelling approach aimed at facilitating the dialog and mutual understanding among stakeholders involved in a common problem of resource management (Bousquet, Barreteau et al. 1999; Barreteau, Antona et al. 2003; Etienne 2011). It proposes to co-construct simulation tools integrating stakeholders' multiple perspectives and to use them to enhance exploration of possible scenarios in an iterative and adaptive process. Two kinds of models or simulation tools are often combined: Role-Playing Games and Agent-Based Models. These models are seen as "intermediary objects" aimed at facilitating confrontation and integration of knowledge and perceptions on the issue at stake.

2. The Forage Rummy

The Forage Rummy (Martin, Felten et al. 2011) is a game-based approach used to help farmers and scientists to design new farming systems adapted to the emergent environmental stakes. The "Forage Rummy" is a card game where players explore various combinations of forage and animal cards. While relying on empirical combinative knowledge of farmers and extension services, forage systems designed by participants are assessed regarding their technical feasibility with a science-driven spread sheet.

3. KCP

The KCP method (Hatchuel, Le Masson et al. 2009) was developed on the basis of Concept-Knowledge (C-K) design theory (Hatchuel and Weil 2009) to enhance design in industrial firms. This theory views design as an iterative process between "*Concepts*" (C), i.e. proposals partly unknown to be designed, and "*Knowledge*" (K), i.e. proposals that can be assessed by anyone as being true or false. This theory makes it possible to formalise a reasoning that starts with a *Concept* and that generates a variety of innovative alternatives. KCP consists of workshops of structured collective exploration following three steps: a Knowledge-phase that builds upon internal and external knowledge; a Concept-phase grounded by surprising and strongly contrasting propositions that orient creativity (*concept projectors*); and a Proposal-phase aimed to synthesise the results and elaborate a design strategy.

Table 1 – Description of the three methods

	ComMod	Forage Rummy	KCP
Participants	Stakeholders involved in a common problem of natural resource management and researchers About 15 people	Farmers, extension services and researchers Less than 10 people	Originally participants came from the same industrial firm. In a farming system context they are stakeholders involved in a territorial project (the collective does not pre-exist). 20-30 people
Objectives of the method	Facilitate mutual understanding among stakeholders Accompany the design of new rules for resources management	Design more sustainable forage systems or farming systems adapted to climate change	Foster the collective design of a sustainable agro-ecosystem
Procedure and tools	Phase 1: Individual and collective interviews to understand stakeholders' perceptions, practices, decision making processes and social interactions Phase 2: workshops based on role-playing games, agent-based models and scenario exploration	Farmers combining technical options within a card-based game to design more sustainable production systems, whose technical feasibility is assessed with the help of a science-driven spread sheet	Method based upon a design theory (CK theory). Workshops organised in 3 phases to share knowledge, explore new concepts and build a collective design strategy
Knowledge used	Mainly stakeholder empirical knowledge	Farmers' knowledge in combining technical options (but it remains tacit). Scientific knowledge to assess the combination designed by farmers through the spread sheet	Sharing of empirical knowledge brought by participants as well as knowledge from the Internet and external experts. Identification of knowledge gaps
Expected outputs	Individual and collective learning, constructive dialogue, improved relationships between stakeholders and proposal of integrative and negotiated solutions. Problem reframing. New values created by highlighting their mutual interdependences. Managerial options to improve the collective governance	New production systems, showing more sustainability. Performance criteria are clearly defined at the beginning and do not change	Increase of stakeholder knowledge to solve the problem. Proposal of a collective design strategy: identify shared objectives, involve relevant stakeholders and partners, guide knowledge exploration, identify new value potentials and performance criteria, propose managerial options

Results

Analysing the design processes in the three case studies

1. Designing new rules for resources management in Thailand with ComMod

This experiment was conducted in mountainous Northern Thailand in the context of a conflict between the board of a National Park being established and two Mien communities located nearby, whose livelihoods depended on forest products (Barnaud, Trébuil et al. 2008). In a context of strong mistrust, the conflict was focused on the future boundaries of the park. A ComMod approach was conducted by researchers to facilitate the dialogue between the villagers and the park board and to accompany their on-going negotiation (Barnaud, Le Page et al. in press).

A role-playing game was designed by the researchers. At each gaming round, local farmers allocated their family labour, opened (or not) new farming plots in the forest, allocated crops and then, collectively went and picked up resources in the forest. Two scenarios were played: with and without the park. No social rules were imposed: the farmers organized themselves as they wanted. The aim was to get the villagers' feedback on the model and prompt them to modify it, and to stimulate exchanges among them about the park establishment and about the governance for resource management. The game was then translated into a computer agent-based model that allowed the exploration of various scenarios testing different innovative rules for the management of forest resources. These two simulation tools were combined in several successive workshops with villagers only, with park officers only and then with all of them in a final workshop.

In this process, the role-playing game and the computer agent-based model were seen as a means to trigger a learning process among stakeholders. This "usable" model was not a consensual or collective representation of the system but rather a continuously evolving representation that allowed the expression of diverse perceptions. When facilitating the process, the researcher paid attention to the social interactions among the participants and avoided the interests of the less influential villagers being overlooked.

This ComMod process increased the protagonists' awareness of their interdependencies in the issue at stake and enhanced mutual understanding among them. The Role-Playing Game offered them an opportunity to address a conflicting issue in a non-threatening environment. However, the use of a spatial representation kept them thinking in terms of segregated space and focusing on the issue of boundaries. With the computer simulations, exploring the effects of different rules on social and ecological indicators, they started to look also at the rules that could be enforced in the park and to think in terms of multifunctional space (Barnaud, Lepage et al., in press). Creatively reframing the issue at stake generated a move to an integrative mode of negotiation in which the protagonist could explore more win-win solutions.

2. Designing sustainable forage systems in South West France with the Forage Rummy

The Forage Rummy was implemented with farmers and extension services in the South of France (Midi-Pyrenees) to explore and design forage systems more sustainable regarding climate change. It was used during two-hour workshops involving farmers or extension workers. The research team who designed the game started with presenting climate change scenarios then the game and its tools, i.e. sticks and cards used to represent forage production and livestock resources. These rules have an important role in the design as they define design parameters such as the production type (it was compulsory to cultivate all the land of the farming system; calving had to be staggered…) or the fact that grassland should represent the most important part of the land surface "*because it was what society wanted*". Finally, the evaluation criterion of the result of the design process was provided by the game designer: farming system autonomy assessed by the feeding stock at the end of the year.

To design of forage systems adapted to a given scenario, players defined calving periods and livestock productivity to reach the scenario objectives. They chose the corresponding "livestock" sticks. Forage cards were then introduced to define the ration of the herd for each period. Then, players selected sticks among 15 to 30 sticks available for grassland management sequences, indicated surfaces for each stick they chose in order to provide the flock with sufficient feeding all along the year. In the course of the design process, combinations were assessed by researchers with the help of a spread sheet for their biophysical feasibility. Finally players could modify the "feed ration" cards, the forage and animal sticks initially chosen in order to test new combinations. They could thus get closer to what they considered as the most adapted farming system, which meant for the research team a farming system which was "relevant, acceptable and feasible in the context of the scenario".

The process ended up with a (or several) farming system(s) considered as innovative, but also "*reflexive and interactive analysis by farmers and extension services*" (Martin, Felten et al. 2011) which is considered by the game designer as enhancing their adaptive capacity.

3. Collective exploration of the ecological potential of a farming system in the west of France with KCP

A KCP workshop was organised to support the development of a project launched by an agricultural cooperative in the West of France (Poitou-Charentes). In a context of agricultural intensification and specialisation having significant impacts on biodiversity and water quality, the cooperative initiated a partnership with researchers in ecology to launch a farming system innovation project. The researchers proposed to set up a territorial supply chain of Lucerne based forage in order to foster the reintroduction of grasslands in the cereal plain as it could improve various ecological regulation processes (Bretagnolle, Gauffre et al. 2011). This proposal was not easy to implement as cereal growers considered grasslands as non-productive areas. Moreover knowledge was missing to define crop management indications to maximize ecosystem services and adapted governance rules (Berthet Elsa, Bretagnolle et al. 2012).

The KCP workshop was organised by some cooperative members and researchers, who agreed on the participants: cooperative board members, technicians and farmers; researchers; local authorities and extension services. This workshop was an opportunity to bring together stakeholders who did not know each other before, but also to confront the cooperative's project to external people. The K-phase and C-phase were organised on a single day.

The K-phase was organised to review the cutting-edge knowledge about Lucerne production and environment. Six expert presentations were collectively debated with the whole group. Prior to the workshop, a preliminary exploration using C-K formalisation was carried out by the facilitator in order to identify the *initial concept* and the four contrasting *concepts projectors*: for instance, "premium quality Lucerne", or "a Lucerne that farmers like to produce". They were validated by the organising committee before the workshop, and then confirmed by the discussion during the K-phase. They drove participants to identify the need for external knowledge useful for the project. Then for the Proposition-phase, the facilitator carried out a thorough analysis of the results. The aim was to analyse the knowledge capitalised and to identify some frequently recurring and innovative propositions. The results were presented to the organisation committee then to all workshop participants.

Before this workshop, the cooperative had planned to implement the project as it was used to, and had imagined a classical contract for Lucerne production with conventional practices. An expected outcome of the workshop was to re-open the alternatives for the implementation of the project (various Lucerne production requirements assessed with regards to various ecosystem services), although it did not clearly define a project implementation strategy. The solutions proposed were not focused on trade-offs between forage production and nature conservation, but rather on the identification of new values that could be collectively created by farmers, such as enhancing pollination or improving water quality.

Applying Charue-Duboc et al. framework for the comparative analysis of design processes carried out with the three methods

We propose to highlight the shared characteristics and differences between the three methods with regard to the three following dimensions: managing knowledge for exploration, organising for exploration and creating new value spaces (Table 2).

It is important to notice that each method has actually contrasting objectives, even if they all belong to "collective design methods" and therefore have two perspectives: a cognitive and a social one. Hatchuel (2005) states that each collective action has two dimensions: *knowledge* and *relations*. The ComMod method is rather turned toward the *relation* dimension in a problem-structuring mode, trying to improve the interaction between stakeholders to trigger a creative reframing of the issue at stake. However the participants drew several solutions and new rules for improving the collective governance. In the Forage Rummy, the final outcome is the design of innovative farming systems rather than the validation of pre-existing models. Thus the objectives are mainly turned toward *knowledge* creation and learning processes. In the KCP workshop, the *knowledge* dimension is more emphasized. However the expansion of grassland properties extended the design spaces of each stakeholder and made it possible to identify of a common ground. One of the outcomes of the KCP workshop was the constitution of a "design group" for the sustainable management of the agro-ecosystem. This analysis suggests that these design methods could be combined: the KCP could help designing scenarios or ComMod could be applied to sustain the development of collective design workshops.

Regarding the contribution to exploratory innovation, the kind of knowledge explored and the identification of new evaluation criteria of the design process results are important dimensions to consider when characterizing the type of design regime each method supports. In the Rummy workshops, the evaluation criteria for the farming system designed during the game evaluation criteria are pre-defined, which can be related to a rule-based design regime. However new knowledge can be brought either by researchers or farmers. ComMod fosters the identification of new criteria during the design process but does not lead the stakeholders to look for breakthrough knowledge. Regarding KCP, it conduces to the exploration of various kinds of knowledge and explicitly aims to design new criteria for defining "performance", which is characteristic of an innovative design regime.

Table 2: comparison of the three collective design methods

		ComMod	Forage Rummy	KCP
Managing knowledge for exploration	**Shared characteristics**	Facilitate the sharing of knowledge between various stakeholders of a farming system		
	Differences	Exchange of local and empirical knowledge among the stakeholders => reframe the problem	Academic knowledge to design the game essentially frames the problem Empirical knowledge brought by farmers Objectives and evaluation criteria predefined	Local/external and empirical/academic knowledge shared in the K-phase Identification of knowledge gaps The identification and discussion of the initial concept is a way to reframe the problem
Organising for exploration	**Shared characteristics**	Facilitators are researchers The facilitators' knowledge influences the learning processes to various degrees, and more or less explicitly		
	Differences	Use of Role-Playing Games => foster a particular type of "experiential learning" (Kolb 1984): belonging to a complex system and being aware of interdependencies => opens innovative ways to look at situations and problems Alternate phases of simulations and phases of open discussions => modifications of the game and emergence of new fields to explore.	Game which rules and features are pre-defined but can evolve during the design process The researchers who do the facilitation also brought their own knowledge in agronomy	Opening and exploration of new fields thanks to *concepts projectors* The two roles (facilitator and experts) are explicitly played by different researchers
Creating new value spaces	**Shared characteristics**	New values are explored to involve stakeholders in the innovation process		
	Differences	Innovation at the territorial level Problem-structuring => improve the interaction between stakeholders to trigger a creative reframing of the issue at stake	Innovation at the farm level New values essentially related to adaptation to climate change	Innovation at the territorial level Identification of new attributes of grassland => extend the design spaces of farmers and naturalists to highlight common ground

Toward a reflexive framework to analyse collective design processes

As a result of this comparative process, we propose to specify the three dimensions proposed by Charue-Duboc et al. (2010) into more detailed items which ought to be questioned to analyse collective design processes (Table 3). We broadened the third category and named it “expected outcomes” in order to include other aspects about contribution to radical innovation and foster reflexivity.

Table 3 – A reflexive framework to analyse collective design processes

1. Managing knowledge for exploration
• How are existing and induced knowledge managed? • How are knowledge gaps identified? • Is the knowledge produced rather generic or local? Is it radically new? • How is knowledge framed and formalised? o What are the methods and tools to organise share and capitalise knowledge? o Are models used and how?
2. Organising for exploration
• How are exploratory fields identified? What are the methods and tools developed to facilitate innovative exploration? • Who are the participants? How are they chosen? How are the relations between participants and their dynamics taken into account during the process? • What is (are) the role(s) of the researchers in the design process? Are they facilitators, experts…? To what extent is the situation predetermined and the interactions between participants regulated?
3. Expected outcomes
• What are the objectives targeted by the method and the outcomes expected? • What kind of learning is made possible by the method? • Are evaluation/performance criteria proposed initially or elaborated during the design process? Are initial presumptions and values questioned? • Does the method make it possible to identify new value spaces? • Does it foster explorative/exploitative innovations? • Do these innovations have impacts on organisational and social change?

Discussion of the framework and future challenges

The framework we propose in this paper assesses specifically the propensity of design methods to foster exploratory type of innovation. Theoretically grounded in the framework of Charue-Duboc et al. (2010) developed to manage exploration, it was enriched thanks to the comparison of three design methods on the basis of their advantages and limits regarding this specific aspect of innovation. We have shown in particular that some tools and methods, in some contexts, are prone to help people think "out of the box" at different level or on different aspects. This is often related to the degree to which the tools are framed and how open and flexible this frame is. A less flexible frame in terms of performance criteria might reduce the opportunity to produce innovation at a different scale than the system to be designed, but it might produce more operational systems. However, there is obviously no "one size fits all" method. The same method will have different impacts in different contexts or at different stages of a given process. Moreover, even in an exploratory innovation process, some stages of more technical reflexions in a problem-solving mode can be useful for exploration (for example to help people make things concrete or feel the limits of a technical solution).

This framework also allows looking jointly at knowledge dynamics and social relations in innovation design processes, as suggested by Hatchuel et al. (2005). It allowed us to highlight in the three case studies how these two dimensions were interconnected. The origin of knowledge, its formalization and its role in the process is indeed closely linked to the social relations between the researchers and the participants, and among the participants themselves. Here again, there is no "one size fits all" method, but a diversity of methods that could be combined creatively.

Last but not least, our framework can be used as a tool to foster reflexivity in design methods. It helps questioning the ambitions and practices of the process, the role of the facilitators and the impacts of their choices (regarding objectives, methods, participants, knowledge formalism, etc.). A challenge for reflexivity in innovation design is that the objectives are not clearly known at the beginning of the process (van Mierlo, Arkesteijn et al. 2010). We believe that although we have to take these uncertainties into account, it remains essential to question the ambitions of a design process, especially the implicit ones, even if they are subject to evolution. This is what we propose in the third part of our framework. This third part also asks to what extent initial presumptions and values are questioned and collective rules can be shaped.

As for the future challenges, we identified two next steps to further develop and improve our framework. First, we would like to apply it to a greater diversity of design methods and case studies. We believe that to be operational, a framework should be not only theoretically but also empirically grounded. Second, it could be improved with regard to reflexivity stakes, following the recommendations by Bos and Grin (2008). Moreover as van Mierlo et al. said, monitoring should be integral part of the design process. The participants should have their say in the reflections regarding the methods and their effects, so that they could learn themselves how to tackle the challenges of uncertainty in agri-environmental innovations.

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